

# Pulmonary Inflammatory Hyperinflation in Infants

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PATIENTS LESS than three years of age respond to pneumonitis of almost any type, at least initially, by acute, diffuse respiratory tract hyperinflation. This diffuse reaction is characterized by obstructive changes occurring between the alveoli and the terminal bronchioles.<sup>1,2,4,7</sup>

There are certain roentgenographic manifestations of the condition.

The cause of overexpansion of the lungs—also called acute emphysema, hyperaeration, acute airway obstruction and diffuse air-trapping—is not understood completely. Owing to the small size of terminal bronchioles in infants (Figure 1) they can become compromised easily. With inflammation there is bronchial spasm, accumulation of mucus and exudate, and edema and infiltration of interstitial tissues which decrease airway patency. Since bronchioles enlarge with inspiration and narrow with expiration<sup>5</sup> a mechanism for air-trapping exists. Inspiration superimposed on previous incomplete expiration adds to the state of excess inflation.<sup>4</sup> McLean<sup>6</sup> described a mechanism of microemphysema due to multiple focal complete bronchiole obstruction, with aeration provided by adjacent alveolar units via the pores of Cohn. All the foregoing factors may contribute to the production of hyperinflation.

## CLINICAL FEATURES

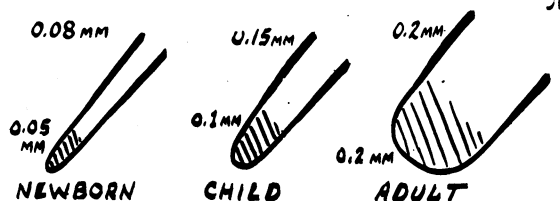
Hyperinflation may occur with upper or lower respiratory tract disease either acutely or chronically (Table 1). Classically, upper tract disease manifests itself primarily by inspiratory difficulty,<sup>2</sup> and lower tract disease primarily by expiratory difficulty. Except for this distinction clinical findings can be quite nonspecific in either category, particularly in obstruction so severe that very little air is exchanged.

The clinical manifestations of acute lower inflammatory hyperinflation include tachypnea, prolonged expiration, expiratory grunting, wheezing, subcostal retractions and any combination of auscultatory sounds. These findings occur early, represent a diffuse reaction and are seen in almost all cases in infants under 24 months of age. There is a decreasing incidence up to approximately 36 months.

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• In infants less than 3 years old pulmonary hyperinflation can be a clinical and radiological sign of acute pneumonitis. It is an early, nonspecific occurrence in the presence of inflammation. The most reliable radiologic signs include flattening and undulation of the diaphragm, mediastinal elongation and narrowing, and a cardiac outline completely visualized above the diaphragm.

## ALVEOLUS-BRONCHIOLE ANATOMY



## CHANGES WITH RESPIRATION



Figure 1.—Diagrammatic representation of the alveolus (shaded area) and the terminal bronchiole in different age groups. Inspiratory widening and expiratory narrowing are depicted.

TABLE 1.—Inflammatory Obstruction

Upper Respiratory Tract	Lower Respiratory Tract
Acute	Acute
Epiglottitis	Hyperinflation of acute pneumonias
Croup	
Foreign body	
Abscess	
Chronic	Chronic
Polio	Asthma
Foreign body	Bronchiectasis
Abscess	Et al.
Tumor	
Anomaly	

**TABLE 2.—Radiologic Signs of Hyperinflation**

Reliable Signs	Less Reliable Signs
Flattened diaphragm	Hyperlucent lungs
Undulation or ripple of diaphragm	Bulging interspaces
Narrow and elongated mediastinum	A-P chest diameter
High perched position of heart	Lack of tracheal kinking
Upper airway must be open	No apparent thymus
	Depressed liver and spleen
	A-P angle of ribs

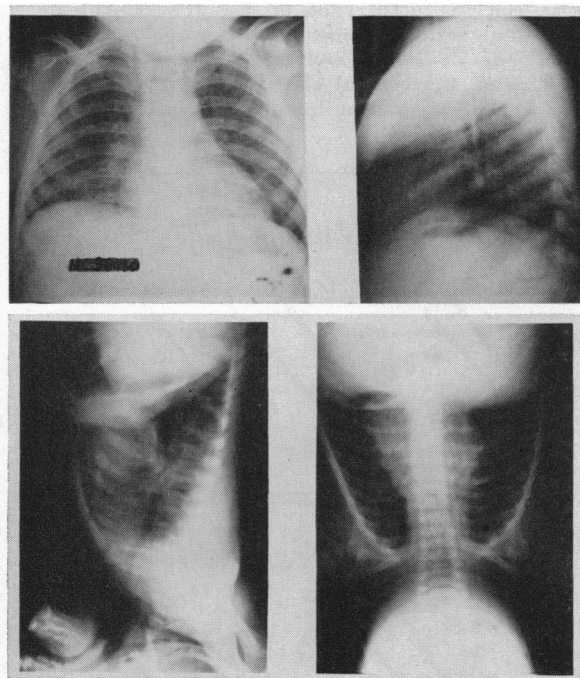


Figure 2.—*Above*, normal chest films in case of asymptomatic child. Note the round and smooth form of the diaphragm in both views. The lower cardiac outline is hidden by the high diaphragm. *Below*, the diaphragm is flattened and uneven. The lateral film demonstrates a normal epiglottis and larynx.

The patient was a 6-months-old boy with fever, rales, coarse breath sounds and severe expiratory wheezing.

#### RADIOLOGICAL EXAMINATION

Upright frontal and lateral films are obtained routinely. When this is not possible two frontal films are taken. For a valid diagnosis two films taken at the same examination should reveal the signs of hyperinflation.

An appropriate lateral chest film includes the epiglottis and larynx (Figure 2). This is helpful in ruling out upper tract abnormality which may cause roentgenographic manifestations similar to those of lower tract disease.

Changes in the diaphragm and mediastinum are the best radiographic signs (Table 2). Flattening of the diaphragm is seen best on the lateral film.

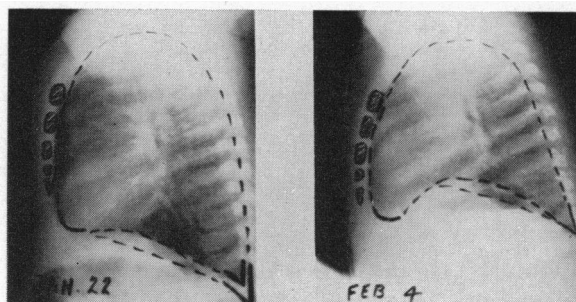


Figure 3.—*Left*, the diaphragm is depressed and uneven on this film of a girl 26 months of age who had fever, prolonged expiration and expiratory grunting. *Right*, films of same infant two weeks later when clinically normal. Note the high, smoothly arched diaphragm.

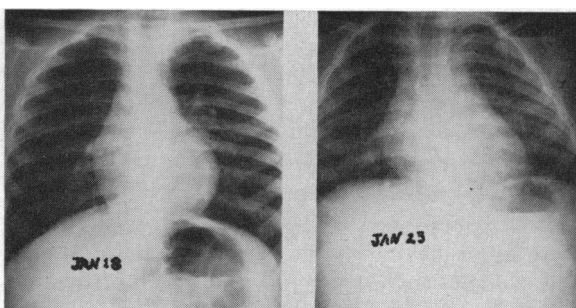


Figure 4.—Film at left taken in case of a 24-month-old boy with cough, tachypnea and severe expiratory distress with wheezing and grunting. The slightly lordotic film shows diaphragm depression with rippling on the right. The heart is perched high. *Right*, film of same patient five days later when clinically normal.

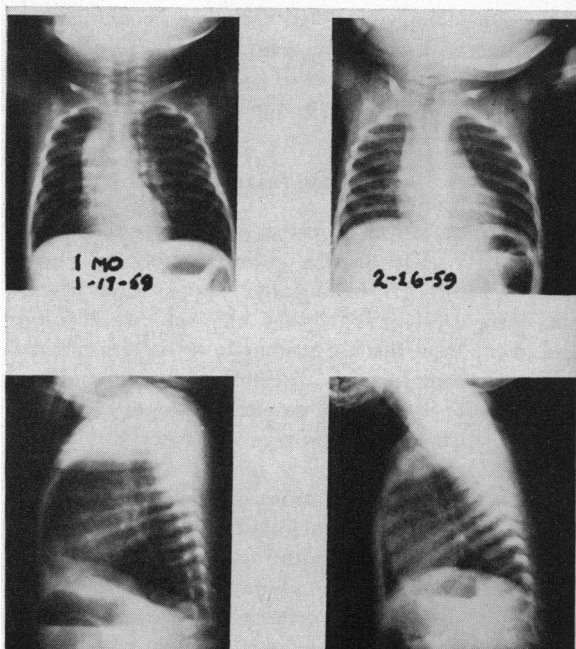


Figure 5.—Two films at left are of a 1-month-old girl with rapid, noisy breathing and expiratory grunting. Note the flattened diaphragm and narrowed mediastinum. At right, films of same infant four weeks later when asymptomatic. The mediastinum is wider and the diaphragmatic curvature is normal.

Hyperinflation is suspected when the costophrenic angle is not parallel with the sternophrenic attachment and when undulation or rippling (Figures 2 and 4) replaces the smoothly rounded form of a normal diaphragm. On the frontal view, undulation most often involves the right hemidiaphragm.

Elongation and narrowing of the mediastinum results from the stretching of the structures by the increase in vertical chest diameter and from compression of the same tissues by the overinflated lungs. In such a situation the thymus is inconspicuous and the heart appears high atop the depressed diaphragm (Figure 2).

Certain other signs are less reliable. Although some investigators have reported<sup>8</sup> bulging inter-spaces, the phenomenon is rarely seen. Hyperlucency of the lungs is a function of technique. The other listed signs are helpful, but variable. The level of the diaphragm (frontal view) can be misleading, but in general hyperinflation should be suspected if the level is below the sixth rib anteriorly and the ninth rib posteriorly.

Hyperinflation is found early in the disease process and may be the only finding (Figures 4A and 5A). In the course of time the lungs may show hyperinflation with accentuation of perihilar interstitial markings or with focal consolidation. Thereafter hyperinflation usually diminishes, sometimes despite a persistence or even an increase in parenchymal infiltrations.

Of 100 consecutive chest films taken at Santa Clara County Hospital in cases of infants with respiratory distress as a chief complaint, 80 showed hyperinflation. Pulmonary infiltrate of some type was seen in 45 of the 80, and in the remaining 35 hyperinflation only was noted. Of the 20 films not showing hyperinflation, ten were considered normal and ten showed focal or diffuse consolidations.

Often in cases of hyperinflation the liver and spleen are palpable at lower than normal positions owing to the depression of the diaphragm. A disproportionately low liver edge in the presence of a large heart should lead to a consideration of cardiac failure.

## DIFFERENTIAL DIAGNOSIS

Inflammatory hyperinflation of the lower respiratory tract has been observed in cases of acute pneumonia due to pneumococcus, streptococcus, staphylococcus, H. influenza, pertussis, measles, interstitial pneumonia, aspiration syndrome, congenital pneumonia and acute bronchiolitis. It has been seen during the acute phases of chronic recurrent pneumonia in infants with cystic fibrosis, in hypogammaglobulinemia, in milk allergy syndrome, in lipid pneumonia, in tracheo-esophageal fistula and in other similar respiratory problems.

Hyperinflation has not been observed in uncomplicated cases of hyaline membrane disease, since complete obstruction in the pre-alveolar area causes resorption atelectasis with decreased lung volume. Records of the cases of seven patients less than 36 months who had miliary tuberculosis were reviewed and in none of them was there evidence of over-expansion of the lungs.

Some investigators<sup>3</sup> have reported hyperinflation concomitant with cardiac septal defects, but have noted that superimposed infection may have been the cause.

In a few cases radiographic findings similar to those of hyperinflation have been noted in infants with acidosis, dehydration and hypovolemia.

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